Unusually heavy snow for November occurred on the 8th and 9th in portions of central-southern Michigan, where in the area of heaviest fall amounts up to nearly 20 inches were measured, the greatest depths ever reported in that section so early in the month. Also about the 18th to 20th unusually heavy snow occurred over portions of northern Oregon east of the Cascade Mountains and the adjacent sections of Washington and Idaho, the falls in some cases being the greatest of record for November, and nearly equaling the average annual fall.

RELATIVE HUMIDITY.

The relative amount of moisture in the atmosphere was above the normal over the greater part of the country from the Missouri and Mississippi Valleys eastward, the excess being large in portions of the Appalachian Mountains and the adjoining districts where there was much cloudy, rainy weather. From Texas and the Middle Plains westward to the Pacific the relative humidity was usually much below normal.

Severe local storms.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

Place.	Date.	Time.	Width of path.	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
			Yards.					
Northern Ohio	1			3		Gale and rain	Wires and trees down, cellars flooded, and transportation services interrupted; velocity of wind 54 miles.	Plain Dealer (Cleveland, Ohio).
New Orleans, La.	13					Wind and thunder.	Some damage to roofs and buildings; electric and telephone systems out of commission in various parts of the city; 2 persons injured.	New Orleans Item (New Orleans, La.).
Reform, Ala., and vicinity	16				$5,000	Hail	Severe damage to roofs, and windows; stones weighing 1 pound fell.	The Advertiser (Montgomery, Ala.).
Arkansas (Polk, Clark and Garland Counties).	17	P. m.	(1)	11		Tornadoes	Homes and barns demolished, live stock killed, wire communication interrupted and much timber destroyed; 39 persons injured; damage estimated at thousands of dollars.	United States Weather Bureau official. Commercial Appeal (Memphis, Tenn.).
Rockport, Ind. (near)	18	P. m.	1,760			Cyclone	30 barns and 3 houses destroyed; damage estimated at from $100,000 to $150,000.	Evansville Courier (Evansville, Ind.).
Marshall, Tex. (few miles N. E. of).	18					Tornado	Some property damage	Official United States Weather Bureau.
Portland, Oreg.	19, 20					Ice	Train service blocked, lines, poles and trees down; thousands of phones out of service.	Do.
Boston and vicinity	27, 28, 29.					do	Telephone and electric companies sustain heavy losses; shade and ornamental trees destroyed or greatly damaged; damage to orchards is estimated at well over $1,000,000.	Do.

[1] One hundred yards to one-half mile.

551.515(73)

STORMS AND WEATHER WARNINGS.

EDWARD H. BOWIE, Supervising Forecaster.

WASHINGTON FORECAST DISTRICT.

The month was a notable one for the number of areas of high and of low pressure to cross the Washington forecast district. For the country at large, 25 separate and distinct areas of low barometer appeared during the month, while as to areas of high barometer there were 14. Many of the LOWS had their origin in and were offshoots from the subpermanent LOW of the North Pacific, and have been classed as LOWS of either the Alberta or North Pacific type, from which there developed a considerable number of secondaries. There was but one LOW of tropical origin, and it was only of moderate intensity. It had its origin over the ocean somewhere east of the Bahamas and it disappeared over the southeastern portion of the Gulf of Mexico. The HIGHS of the month did not bring unseasonable cold weather to the Washington forecast district, and the cold waves which occurred were confined to the northern border states.

A storm of considerable intensity was central the morning of the first day of the month over the central Ohio Valley, with the lowest barometer at its center 29.46 inches; moving eastward this disturbance passed off the middle Atlantic coast during the night of the 1st and thence followed a path east-northeastward toward the Grand Banks of Newfoundland. This disturbance was attended by strong northeast winds and gales on the lower Lakes and the North Atlantic coast, warnings of which were disseminated. On the 3d a disturbance made its appearance over the western Canadian provinces, advanced rapidly eastward along the northern border and reached the New England States on the 5th. On the 4th when this disturbance was crossing the Great Lakes, southwest storm warnings were displayed on Lakes Erie, Ontario, and southern Huron; the evening of the same day northwest storm warnings were displayed on the Atlantic coast at and north of Delaware Breakwater. This disturbance was attended by shifting gales in the regions where storm warnings were displayed, and it gained great intensity while moving from New England to Newfoundland. The highest velocity reported during the prevalence of this storm was 66 m. p. h. from the northwest on the 5th at New York City.

At 6 p. m. of the 7th, the following advisory information was sent to ports on the Great Lakes:

> Western disturbance central at 4 p. m. over western Kansas will move eastward and probably gain in intensity, attended by fresh easterly winds becoming strong by Tuesday morning with rain and snow. Caution advised. Later information will be sent you to-night if any change indicated.

The 8 p. m. reports showed this storm to have moved to eastern Kansas; and as the pressure gradient was considerable in its northeast quadrant, northeast storm warnings were ordered displayed on southern Lake Michigan, and on the morning of the 8th the display of northeast storm warnings was extended to Lakes Erie, Ontario, and extreme southern Huron. The storm center passed south of the Great Lakes during the 8th, attended by winds of gale force at a number of Weather Bureau stations in the area where warnings were displayed. On the morning of the 9th its center was over Kentucky, and at the same time there were indications of the development of a secondary disturbance off the North Caro-

lina coast. In expectation that the disturbance off the Carolina coast would develop very quickly and move northeastward, storm warnings were displayed at 9:30 a. m. of the 9th on the Atlantic coast at and north of Delaware Breakwater. The disturbance acted as expected, and strong winds and gales prevailed along and off the North Atlantic coast the night of the 9th and during the 10th.

Northwest storm warnings were displayed on Lakes Michigan, Superior, and Huron and southwest storm warnings on Lakes Erie and Ontario at 10 p. m. of the 18th, when a disturbance was central over the middle Mississippi Valley and moving northeastward, with every indication that it would increase greatly in intensity. This disturbance passed rapidly eastward across the Great Lakes as expected, and strong winds and gales occurred as forecast. Northwest storm warnings were also displayed at 2 p. m. of the 24th on the Atlantic coast at and north of Delaware Breakwater, when a disturbance was central over western New York. This disturbance moved rapidly eastward, and the morning of the 25th its center was over Newfoundland. The highest wind velocity attending this storm was 60 m. p. h. from the west during the night of the 24th at New York City.

The evening of the 27th, when a disturbance was central over South Carolina, in expectation that it would gain greatly in intensity and move northeastward, northeast storm warnings were displayed on the Atlantic coast at and north of Delaware Breakwater and on Lakes Erie and Ontario. This storm moved northeastward as forecast, gained great intensity, and 24 hours later its center was off the middle Atlantic coast. Thence it moved north-northeastward and at 8 p. m. of the 29th its center was off Cape Cod. The center of this disturbance passed near Sable Island during the night of the 29th, and the morning of the 30th it was in the vicinity of St. Johns, Newfoundland, where the barometer fell to 28.98 inches. This storm was the severest of the month in the Washington forecast district, causing gales and high tides on the middle Atlantic and New England coasts and attended by general and heavy rain, sleet, and snow in the New England and Middle Atlantic States. The rain, which fell with the temperature below the freezing point, caused damage estimated beyond $1,000,000 to telegraph and telephone lines in New England, and the weight of the ice damaged and destroyed many trees in the cities and forests, the value of which can not be stated. (See p. 612 this REVIEW.)

The winds along the New England coast were from the northeast and of gale force during the 28th and 29th, the highest velocities reported being 76 m. p. h. at Nantucket and 72 m. p. h. at Block Island.

In addition to the warnings for the more important storms hereinbefore enumerated, warnings were issued for disturbances of moderate intensity on other dates. No general cold waves occurred during the month. Frost warnings were issued for Southern and Central States as occasion required.—*Edward H. Bowie.*

CHICAGO FORECAST DISTRICT.

The special features of the weather in the Chicago district during the month of November were the continuation of the drought in the Southwest for the entire period and the abnormally low temperatures in the Northwest during the second and third weeks. The precipitation was in excess only in the extreme eastern portion of the district; and while the dryness in the Southwest was of greatest concern because of lack of moisture for the winter wheat, there was little precipitation in the Northwest also, except during the third week in the northern Rocky Mountain region, when heavy snow prevailed.

Conditions during the first week were generally rather mild, although frosts occurred on the morning of the 2d from the middle Mississippi Valley eastward, as well as in southern Missouri; and they were reported again on the 3d in the latter section and also in extreme southern Illinois. Because of the mildness of the previous season, frost warnings seemed necessary and they were issued for the area affected in due time.

On the morning of the 7th, a cold, high area which had moved southward from Alaska appeared in the Canadian northwest, and for two weeks following, with only slight interruptions, high pressures dominated the weather conditions over the trans-upper Mississippi region, the cold reaching its greatest intensity in Montana on the 19th, where minima were registered ranging from —8° to —26°; and on the 20th the temperature fell to zero in northern Nebraska and central Wisconsin.

Warnings were sent in advance to all interests affected, and railroads and shippers of perishable goods were especially cautioned to protect all goods subject to damage. These advices seemed especially necessary because of the unusually early occurrence of winter conditions in the Northwest. The cold, however, in its movement southeastward moderated rapidly, so that no abnormally low temperatures were registered in the southeastern portion of the forecast district. Warnings to live-stock interests were also disseminated during and previous to the period of severe cold.

Because of the threatened railroad strike and the approach of winter, the fruit interests in the States of Washington and Oregon during the month of October indicated to the Weather Bureau that advices one or two weeks in advance would be to them of the greatest importance, as they wished to hurry their shipments of fruit, especially apples, across the Northwestern States to the main distributing points, such as Chicago, St. Louis, and Kansas City. It was of greatest importance to them to make these shipments in ordinary cars at their own risk so long as the mild weather might continue, as a large amount of money would otherwise have to be spent in protection of their shipments. Under the regulations of the various railroads in the Northwest the shipper of fruit is required to declare at the time he bills his cars whether it shall be shipped at his own risk or at the carrier's risk, and in the latter case an additional charge is made where the carrier assumes the risk of freezing in transit, and in the event extreme weather is encountered the carriers oftentimes equip the cars with oil heaters, and as a result the fruit is sometimes damaged from being overheated.

Under date of November 26, 1921, the Wenatchee Northern Warehouse & Marketing Co., of Wenatchee, Wash., writes as follows:

> The information which you so kindly gave us enabled us to reach a much safer conclusion at the time of shipment whether or not it were possible to avoid the extra expense of paying for the carrier's risk, and the still greater risk of shipping during extreme weather and having the fruit damaged from overheat. You can see, naturally, that the day-to-day reports received from the Weather Bureau are not of the same advantage in this connection, but a prognostication for two weeks in advance give us a good idea of the conditions which may be encountered by cars shipped from day to day in their movement from here to the eastern markets. In fact, we wish that this service might be established definitely. We appreciate very much your interest in this matter and the manner in which your advices were given us.

The *Great Falls Tribune*, Great Falls, Mont., on November 16 includes the following statement:

> According to Great Northern officials warnings of snow and cold waves are received from the Government meteorological bureau in Chicago

from 36 to 48 hours in advance and are ordinarily authentic. Two advices regarding the approach of cold and snow have been received prior to the one received Tuesday. The last one was received last Thursday and the first about a week before.

The warning is issued in the interest of shippers and employees of the road, it was stated, and consequent upon the receipt of such warnings extraordinary precautions are taken in the shipping of perishable goods.

—*H. J. Cox.*

NEW ORLEANS FORECAST DISTRICT.

Small-craft warnings were displayed on the Texas coast on the 17th and on the east coast of Texas on the 9th and were justified.

On the morning of the 18th a trough of low pressure extended from the Lake region to Mexico, with an important center of disturbance over the Rio Grande. It was evident from the distribution of pressure that the disturbance would move rapidly and southeast storm warnings for strong southerly winds, shifting to northerly at night, were issued for the Texas coast. Winds occurred as forecast, changing to north and northwest gales at about midnight of the 18th–19th.

A warning of moderate northerly gales at Tampico and Progreso during the following 24 hours was issued on the morning of the 19th.

Warnings were issued 36 hours in advance of a moderate cold wave which overspread the extreme northwestern portion of the district on the 9th and the remainder of the northwestern portion on the 10th.

On the morning of the 18th, with a disturbance over the Rio Grande and a considerable area of high pressure to the northward, cold-wave warnings were issued for the entire district except southern Louisiana and warnings for live-stock interests were sent to interior sections. The cold wave did not reach the coast and proved to be of moderate character for the most part, although temperatures of 16° to 30° were recorded in the northwestern portion of the district.

On the 21st, after the receipt of midday special observations, cold-wave warnings were issued for Oklahoma, northwestern Arkansas, and the northern portion of west Texas and were extended the following afternoon to include the northwestern portion of east Texas as far east as Dallas. A cold wave occurred in the Texas Panhandle and northern and western Oklahoma but did not extend farther, owing to the influence of a barometric depression on the western slope of the Rocky Mountains and the eastward drift of the area of high pressure. It is interesting to note in this connection that while the influence of the western depression extended east of the Continental Divide so as to prevent the temperature at Denver, Colo., from going below freezing, a minimum temperature of 22° was recorded at Amarillo, Tex., and 28° at Oklahoma City, Okla.

Frost warnings and freezing-temperature forecasts were issued for portions of the district on the 1st, 2d, 7th, 8th, 9th, 10th, 11th, 19th, and 20th. Nearly all of these warnings were verified.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

An area of low pressure which moved from the north Pacific coast southeastward, across Montana, Wyoming, and eastern Colorado, on the 6th and 7th, was followed by a sharp fall in temperature in eastern Colorado, attended by snow flurries, during the 8th. Generally fair weather, however, without important temperature changes, prevailed during the first half of the month, with mostly high pressures over that portion of the district west of the Continental Divide, such LOWS as appeared passing to the northward and eastward.

Another LOW moved southward from British Columbia from the 14th to the 16th, with its center on the morning of the latter date over western Colorado, while the crest of a HIGH of considerable development was over Alberta. Snow was forecast for Colorado, Utah, northern New Mexico, and northeastern Arizona, with a cold wave in northern and eastern Colorado, northern New Mexico, northeastern Arizona, and southern and eastern Utah, and stockmen's warnings were distributed in northern and eastern Colorado. Snow occurred in all of the region indicated, with moderately heavy falls along the eastern slope in Colorado. Owing to a division of the storm and the slow eastward movement of the center which remained west of the Divide, the time of occurrence of the lowest temperatures was delayed 12 to 24 hours. Otherwise, the cold-wave warning was verified except in eastern Colorado. Warning of a moderate cold wave in southeastern New Mexico was issued on the 18th and was fully verified by the morning of the 19th.

From the 18th to the 23d, low pressures prevailed from the north Pacific coast southeastward to eastern Colorado, without any attendant precipitation in this district except in northwestern Colorado on the 19th and 23d and occasionally in northern Utah. A cold-wave warning issued on the evening of the 20th for north-central Colorado failed of verification because that portion of the extensive LOW, already referred to, which was over southern Wyoming remained almost stationary. A moderate cold-wave forecast on the morning of the 23d for southwestern Utah was fully verified during the following 24 hours.

A disturbance of moderate intensity which began to appear in Arizona on the 24th extended northeastward to South Dakota on the 25th, causing rain or snow in northern Arizona, southern Utah, and western Colorado. Occasional light precipitation in central Arizona on the 28th and 29th and in southern New Mexico on the 29th and 30th attended a moderate disturbance which was first noted over Nevada on the morning of the 27th and which had moved to eastern New Mexico by the morning of the 30th.

A cold wave for which warnings had not been issued occurred at Durango on the 18th.

Forecasts of freezing temperature were issued for eastern Colorado on the 1st and 2d which were verified except in the east-central portion of the State on the 3d. The season was so far advanced that warnings of ordinary freezing weather were not considered necessary after the last-named date, except in southern and western Arizona.

Frost warnings were issued for western and southern Arizona on the 16th, 18th, 19th, 20th, and 21st, and for southern Arizona on the 22d, the warning of the 18th containing a forecast of freezing temperature in the northwestern and near freezing in the south-central and southeastern portions of that State. These were verified by the occurrence of frosts or temperatures at which frosts might be expected except in southern Arizona on the 17th and extreme southwestern Arizona on the 21st.

The first damaging frost occurred in the southern portion of Arizona on the 19th, when the temperature fell to 30° at Phoenix and to 36° at Yuma. Light frosts, without warnings, occurred at Phoenix on the 8th and 11th, when the minimum temperature was 43° and 41°,

respectively, and a heavy frost was reported on the 18th, when a minimum temperature of 36° was reached at the same station.—*J. M. Sherier.*

SAN FRANCISCO FORECAST DISTRICT.

Two very distinct pressure types were alternately in control of weather conditions in the Pacific States during November—high pressure over the western part of the United States was dominant during the forepart of the month and low pressure during the latter part.

Except for a disturbance for which southwest storm warnings were displayed in Oregon and Washington on the 4th, the weather was settled and rainless in most sections, with a hot spell in California until the 14th. On that date a disturbance entered the north coast and moved southeastward over the plateau. Its passage was followed by a series of heavy frosts in California extending from the 16th to the 20th. All of the severer ones were covered by warnings. The freezing temperatures did not reach southern California until the 18th, a day later than was expected, due to the sluggish eastward movement of the LOW then centered in Arizona, and one unverified warning of light frost was issued as a result.

Coincident with the passage of this storm was the southward advance of the Alaska HIGH. Colder weather in connection with this movement was foreseen in the northwest, and special warning was sent on the 17th to fruit storage and shipping interests in northeastern Washington of an expected period, with temperatures considerably below freezing. This warning was fully justified by the event.

From the 19th until the close of the month the weather in this district was dominated by the North Pacific low-pressure system which shifted southeastward so as to impinge on the Pacific coast. So plain was the evidence of a change in weather type that advice was issued several days in advance to forestry parties in the high Sierra of impending snowfall that would impede their withdrawal from the mountains.

Southeast storm warnings were put up at Oregon and Washington seaports on the 19th and displayed thereafter with but few interruptions until the 30th. Occasionally they were altered in direction, and on two occasions they were extended to include the California coast as far south as Mendocino. There was one marine casualty of note during this time. The tug *Sea Eagle*, which left San Francisco for Coos Bay on the 16th, never arrived at that port. All that is known regarding her loss is deduced from some of her wreckage washed ashore on the Oregon coast a few miles south of the Columbia River on the 24th.

Forecast problems this month clearly illustrated the value of timely vessel weather reports. Several failures to accurately predict the weather in this district may be attributed to the nonreceipt of such reports. Two ill-advised frost warnings for northern California, those of November 23 and 28, may be explained thus: In the case of the first one it was seen a few hours after the forecast had been made that conditions presaged rain rather than frost, the S. S. *Eldridge* reporting from a position off the southern Oregon coast facts which contained the information requisite for an intelligent prediction. On the other hand, a number of forecasts for California, Oregon, and Washington were influenced in the right direction through the aid derived from a knowledge of conditions over the adjacent ocean.—*Thomas R. Reed.*

MEAN LAKE LEVELS DURING NOVEMBER, 1921.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., December 3, 1921.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1] Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during November, 1921:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.20	579.64	571.80	244.85
Above or below—				
Mean stage of October, 1921	−0.33	−0.22	+0.01	−0.26
Mean stage of November, 1920	−0.28	−0.66	−0.15	−0.38
Average stage for November, last 10 years	−0.39	−0.67	−0.12	−0.60
Highest recorded November stage	−1.31	−3.28	−1.87	−2.97
Lowest recorded November stage	+0.70	+0.46	+1.10	+1.44
Average relation of the November level to—				
October level		−0.20	−0.20	−0.20
December level		+0.10	+0.10	+0.10

[1] Lake St. Clair's level: In November, 574.55 feet.

627.41(73)

RIVERS AND FLOODS.

By H. C. FRANKENFIELD.

Atlantic drainage.—The heavy rains from November 26 to 29 caused decided rise in the rivers of New York and Pennsylvania, although flood stages were not reached in the Hudson River system. Flood stages were also approached or slightly exceeded in the North Branch of the Susquehanna and its tributaries, but the total damage reported was only about $8,000.

Over the South Atlantic drainage area there were no floods except a very moderate one in the Santee River during the early days of the month, due to heavy rains on October 30 and 31. There was no damage. A flood warning on November 28 for the Santee River was not quite justified, probably owing to the dry period that preceded the rainfall.

Mississippi drainage, Ohio branch.—Moderate rains that fell on a previously dry soil from November 24 to 29, inclusive, caused a rapid rise in the upper Ohio River and its tributaries, and flood stages prevailed along the river almost as far as Parkersburg, and also in the vicinity of Point Pleasant, W. Va. Warnings were first issued on November 28, and the crest stages reached did not differ materially from the forecast stages.

The crest stage at Pittsburgh was 25.4 feet, 3.2 feet above the flood stage, at 2 p. m. November 29; at Marietta, Ohio, 34 feet, or 1 foot above the flood stage, at 10 p. m. November 30; at Parkersburg, W. Va., 35.9 feet, 0.1 foot below the flood stage, at 1 a. m. December 1; and 43.5 feet, or 3.5 feet above the flood stage, from 2 p. m. November 30 to 6 a. m. December 1. The flood stage at Point Pleasant was due to the run-off from the Great Kanawha River and had little or no effect on the Ohio River below.

The Monongahela, Kiskiminetas, lower Allegheny, Little Kanawha, and lower Licking Rivers also experienced flood stages.

The total of losses and damage reported in the Pittsburgh district amounted to about $25,000 and in the Parkersburg district to about $10,000.

Heavy rains from November 16 to 18, inclusive, averaging from 3 to more than 6 inches over portions of Indiana, Kentucky, and Illinois, caused unusually rapid rise in the Wabash and White Rivers. Warnings for the